# PARTIAL REPLACEMENT OF CEMENT WITH CORN COB ASH

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**Abstract:** This study concerns the investigation of concrete produced by partial replacement of cement with corn cob ash (CCA). Corn cob ash was obtained and used to replace cement partially in specified ratios of 5%, 10%, 15%, 20% and 25%. Concrete cubes were cast and cured in ages of 7, 14 and 28 days respectively. While concrete beams were cast and cured for 28 days. Compressive strength test was carried out on the cubes and the flexural strength on beam. The results showed that the concrete strength decreased with increasing replacement with the corn cob ash (CCA). The 28 days compressive strength for 5% replacement was 28.78N/mm$^2$, 10% replacement was 26.22N/mm$^2$, 15 % replacement was 22.33N/mm$^2$, 20% replacement was 20.27N/mm$^2$ and 25% replacement was 17.33N/mm$^2$ respectively while its flexural strength for same age for 5% replacement was 9.98N/mm$^2$, 10% replacement was 8.58N/mm$^2$, 15% replacement was 7.82N/mm$^2$, 20% replacement was 6.56N/mm$^2$ and 25% replacement was 5.72N/mm$^2$. The initial and final setting time of OPC-CCA at 10% replacement was observed to be 168minutes and 305minutes respectively. The density of OPC-CCA was also observed to decrease with increasing CCA replacement. The 28 day density for 10% CCA replacement for concrete cube was 2373.33kg/m$^3$ and that of rectangular concrete beam was 2575kg/m$^3$. The specific gravity of CCA was 2.55. It was concluded that CCA can be used as partial replacement for cement in concrete production as well as for walls of building units and other mild construction works, and replacement should not exceed 10% as strength produced above this replacement level may not be adequate for strength requirements.

**Key Words:** Cement, Corn Cob Ash, compressive strength, specific gravity, Partial Replacement.

## INTRODUCTION:

Concrete is the most versatile heterogeneous construction material and the most impetus of infrastructural development of any nation. Civil engineering practice and construction works around the world depend to a very large extent on concrete. Concrete is a synthetic construction material made by mixing cement, fine aggregates, coarse aggregates and water in the proper proportions. Each of these components contributes to the strength of concrete Gambir, (2004). The cost of concrete depends largely on the availability and cost of its constituent with the cost of cement in a cubic meter of concrete being higher than other constituent. In order to reduce the cost of concrete production there is a need to employ the use of agro waste scientifically known as pozzolans as a replacement of cement in concrete. Which in this case we are attempting with (CCA)

## AIM:

The main aim of this study is to investigate the potential of corn cob Ash in partial replacement of cement in the production of concrete.

## LITERATURE REVIEW:

In preparing concrete with maize cob ash, the properties and merits of using this pozzolan in concrete are determine Narmluk and Nawa, (2011). Expressing it another way, it can be said that 7% of worlds carbondioxide (CO2) emission is attributable to cement industry (Olutoge, et al, 2010). Because of the significant contribution to the environmental pollution to the high consumption of natural resources like limestone and the high cost of cement, Raheem, (2010) gave an insight on the maize cob as agricultural waste product obtain from maize, which is the most important cereal crop in sub-saharan Africa according to food and agriculture organization (FAO) data, 589 million tons of maizeare produce worldwide in the year 2000 (FAO record 2012). Nigeria was the second largest producer of maize in Africa in the year 2001 with 4.62 million tons. There had been various effort on the use of maize cob ash (MCA) and other pozzolan as replacement for cement in concrete (Olutoge, et al, 2010) presented a comparative study on fly ash and groundnut husk ash to replace cement in a wake to reduce carbondioxide emission associated with production of cement clinker, another study was presented by (Hassanbeigi, et al, 2012) on the reduction on the partial replacement of cement with maize cob ash which by him is expected to yield a significant reduction in carbondioxide emission.

Corn cob is a readily available biomass that when not disposed of properly can pollute the land, air and water. Typically, corn cob is only use for animal feed and in few cases alternate fuel. Biello, (2008).

## MATERIALS AND METHODS:

### Materials

The following materials were used for this work.

Cement, Aggregates (Coarse and Fine), Maize cob ash, Water

### Methodology

The methods employ in carrying out this research work are listed under the following laboratory work.

### Laboratory test

The tests conducted on both materials were; Standard consistency and setting time of cement and ash, Specific gravity test, Sieve analysis, Batching quantity for mix ratio, Slump test and Compressive strength test.

### Standard consistency test and setting times of cement and ash

400g of cement was mix with relevant water quantity, starting with water content of 30% of dry mass of the cement. The mould was laid on a steel plate and fill using the gauging trowel and the top of the paste was smoothened off. The mould was placed under a plunger in the vicat apparatus. The plunger made contact with top surface of paste and release. The plunger penetrated to a point 5 to 7mm above the bottom of the mould, this process continued until required consistency was achieved.

### Fineness of cement

100g of cement was weighed and sieved continuously through sieve 90microns giving circular and vertical motions till fine sizes completely passed through. The residue left on the sieve was then weighed. This weight did not exceed 10% for ordinary cement which was the required standard. The fineness of cement has an important bearing on the rate its hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface for hydration and hence faster development of strength. This test was carried out to ascertain the quality of fineness of the cement.

### Specific gravity

Specific gravity (Gs) is an important property of fluids being related to density and viscosity. Knowing the specific gravity allow determination of a fluid characteristics compared to a standard, usually water at a specified temperature. This allowed the user to determine if the tests fluid will be heavier or lighter than the standard fluid. The specific gravity of any material is then defined as the ratio of the weight of a given material to the weight of an equal volume of water. The specific gravity of the soil is Ws, the weight of the filled jar plus soil is W1 and weight of jar first filled with water is W2, then submerge weight of soil.

### Procedure

The empty density bottle was weighed to the nearest 0.001g, (W1).

5g-10g of the fine grained soil, ground to pass 2mm Bs test sieve and transferred to the density bottle and weighed to the nearest 0.001g, (W2).

Distilled water was then added to soil in the bottle and shaken vigorously to expel air. Bottle was completely filled with the water and the stopper was replaced. The whole sample was weighed to the nearest 0.001g (W3).

Bottle was emptied and stopper was replaced and weighed to the nearest 0.001g (W4).

Result was tabulated and specific gravity was calculated

**Sieve analysis**

This test method was used primarily to determine the grading of materials proposed for use as aggregates or being used as aggregate. The results are used to determine compliance of the particle size distribution with applicable specification required and to provide necessary data for control of the production of various aggregates products mixtures containing aggregates. The data may also be useful in developing relationship concerning porosity and packing. Accurate determination of material finer than the 75micro millimeter (No 200) sieve cannot be achieved by use of this test method alone. Test method C117 for material finer than 75 micro millimeter sieve by washing should be employed. Refer to method of sampling and testing in specification C637 for heavy weight aggregates. This test method covers the determination of the particle size distribution of fine and coarse aggregates by sieving. The values stated in SI units are to be regarded as the standard. The values in parentheses are provided for information purposes only. Specification E11designates the size of sieve frames with inch units as standard, but in this test method, the frame size is designated in SI units exactly equivalent to the inch units.

**Compressive strength test**

Compressive strength tests were carried out on concrete cubes of (150mm×150mm×150mm) in a 1560KN capacity (ELE) electro hydraulic pump powered testing machine which satisfies the BS 1620: (1964). The cubes were weighed and placed in the compression testing machine with the plates placed at top and bottom of the sample for even distribution of load. The cube was loaded by pumping using the pumping lever and the readings were observed until there was no further progressive reading of the dial gauge. The compressive strength was calculated for each cube sample using the formula:

$$\text{Compressive strength} = \frac{\textit{crushing load }(N)}{\textit{Net Area of cube}} \quad \text{.........(ii)}$$

**Flexural test**

The concrete beams were weighed before testing and the densities of the concrete beam measured and the flexural test was carried out on concrete beam of 500mm (length) x 100mm (breath) x 100mm (height) having varying composition of corn cob. The strength values were the average of three specimens tested in each case using a manual controlled Compact- 1500 compression machine made in England by Engineering Laboratory Equipment Limited (ELE).

Flexural strength is a measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 500 x 100 x 100mm concrete beam a span length at least three times the depth. The flexural strength is expressed as modulus of rupture (MR) impsi (MPA) and is determined by standard test method ASTM C 293 (centre- point loading).

**RESULTS AND DISCUSSION:**

Result - The result obtained from various laboratory tests are presented below:

Table 4.1 Material properties.

| Material | Specific gravity | Density (kg/m3) |
|---|---|---|
| Water | 1.00 | 1000 |
| Cement | 3.15 | 3150 |

| | | |
|---|---|---|
| CCA | 2.55 | 2550 |
| Sand | 2.52 | 2520 |
| Gravel | 2.63 | 2630 |

4.2 Grain size analysis

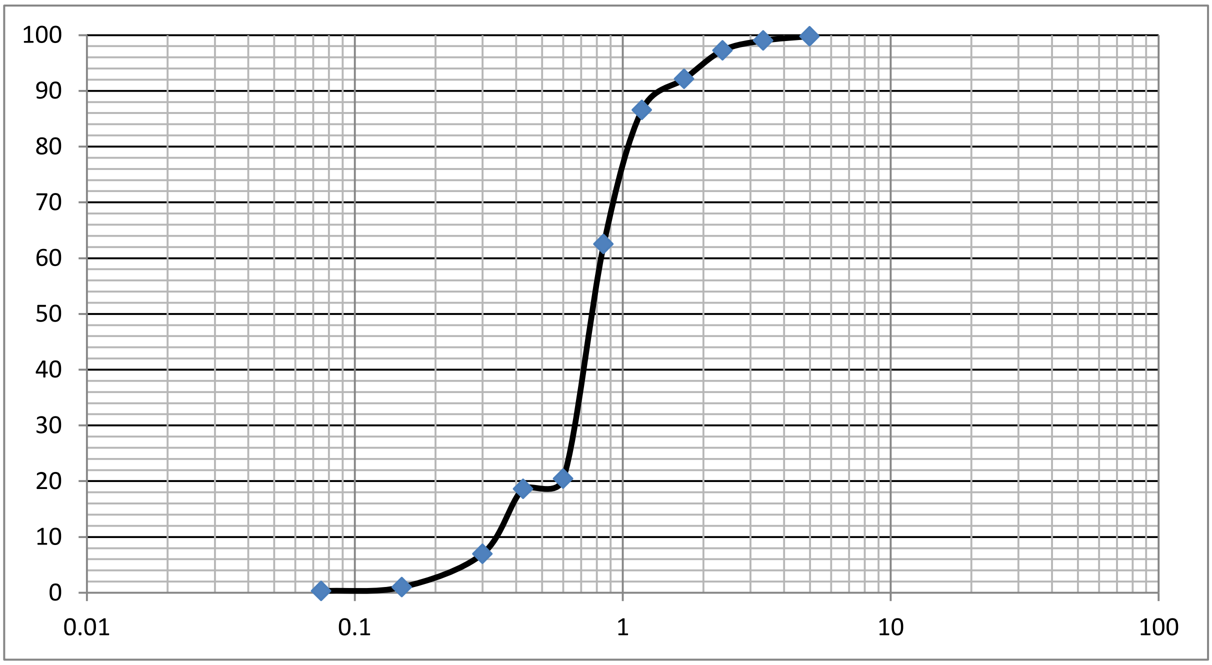



Figure 4.0: grain size analysis of river sand.

The initial and final setting time of ordinary Portland cement replaced with corn cob ash in percentages was performed and observed to be as shown in the table below.

Table 4.2: Summary of initial and final setting times of OPC-CCA

| CONTENT (%) | 0 | 5 | 10 | 15 | 20 | 25 |
|---|---|---|---|---|---|---|
| INITIAL (Min) | 125 | 155 | 168 | 175 | 184 | 190 |
| FINAL (Min) | 258 | 277 | 305 | 348 | 367 | 394 |

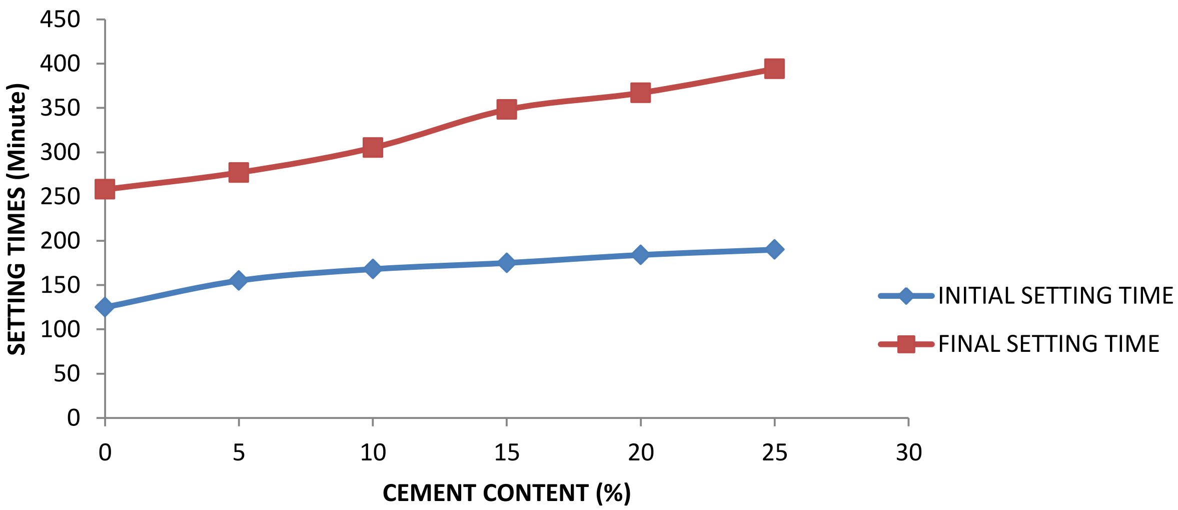



**Figure 4.1: variation in setting time of OPC-CCA**

The setting time of OPC-CCA was observed to increase with increase in corn cob ash.

Table 4.3: Summary of compressive strength of concrete cubes using percentage replacement

| Combination | 7days (N/mm2) | 14days (N/mm2) | 28days (N/mm2) |
|---|---|---|---|
| 0%CCA:100%Cement | 27.04 | 28.93 | 30.31 |
| 5%CCA:95%Cement | 23.11 | 25.45 | 28.78 |
| 10%CCA:90%Cement | 21.89 | 22.20 | 26.22 |
| 15%CCA:85%Cement | 18.56 | 18.71 | 23.33 |
| 20%CCA:80%Cement | 16.00 | 16.98 | 20.27 |
| 25%CCA:75%Cement | 13.67 | 14.07 | 17.33 |

The compressive strength of grade 30 of concrete cube decrease from 27.04N/mm2 (0% corn cob ash) to 23.11N/mm2 (5% corn cob ash), 21.89N/mm2 (10% corn cob ash), 18.56N/mm2 (15% corncob ash), 16.00N/mm2 (20% corn cob ash), and to 13.67N/mm2 (25% corn cob ash) at 7 days cure and from 28.93N/mm2 (0% corn cob ash) to 25.45N/mm2 (5% corn cob ash), 22.20N/mm2 (10% corn cob ash), 18.71N/mm2 (15% corn cob ash), 16.98N/mm2 (20% corn cob ash) and 14.07N/mm2 (25% corn cob ash) at 14 days cure and from 30.31N/mm2 (0% corn cob ash) to 28.78N/mm2 (5% corn cob ash), 26.22N/mm2 (10% corn cob ash), 23.33N/mm2 (15% corn cob ash), 20.27N/mm2 (20% corn cob ash) and to 17.33N/mm2 (25% corn cob ash) respectively.

The figure below is a graph of the variation of compressive strength results of grade 30 concrete with corn cob ash.

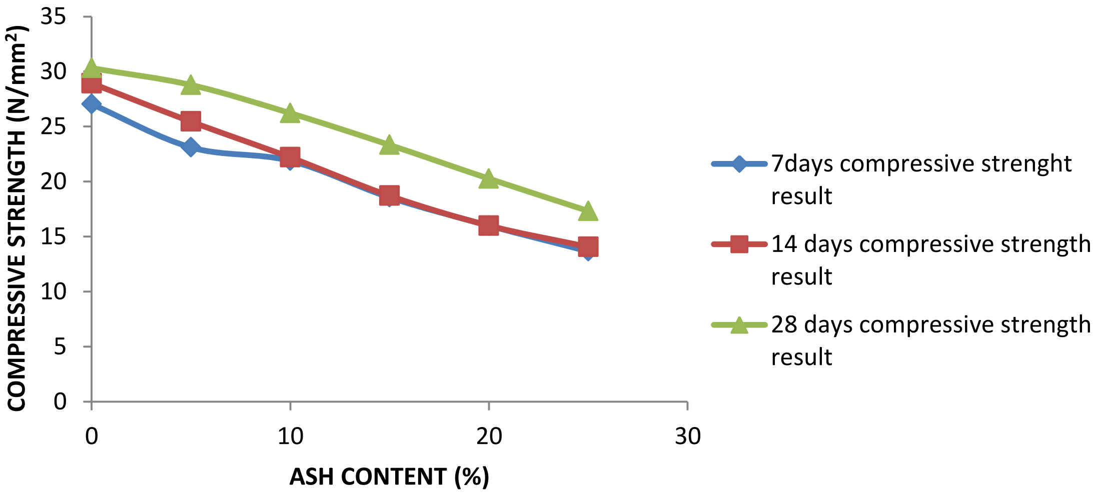



**figure 4.2 variation in compressive result of grade 30 concrete with corn cob ash**

The compressive strength of concrete cubes of grade 30 was also observed using rebound harmer (RBH) and summarized in the tables as shown below.

Table 4.4: Summary of 7 days compressive strength of OPC-CCA of concrete grade 30

| Ash content (%) | RBHmax (N/mm2) | RBHmin (N/mm2) | RBHavr (N/mm2) | Compressive strength (N/mm2) |
|---|---|---|---|---|
| 0 | 26.4 | 20.1 | 23.25 | 27.04 |
| 5 | 24.9 | 18.7 | 21.8 | 23.11 |
| 10 | 22.1 | 16.1 | 19.1 | 21.89 |
| 15 | 20.6 | 14.7 | 17.65 | 18.56 |
| 20 | 18.00 | 12.5 | 15.25 | 16.55 |
| 25 | 16.6 | 11.3 | 13.95 | 13.67 |

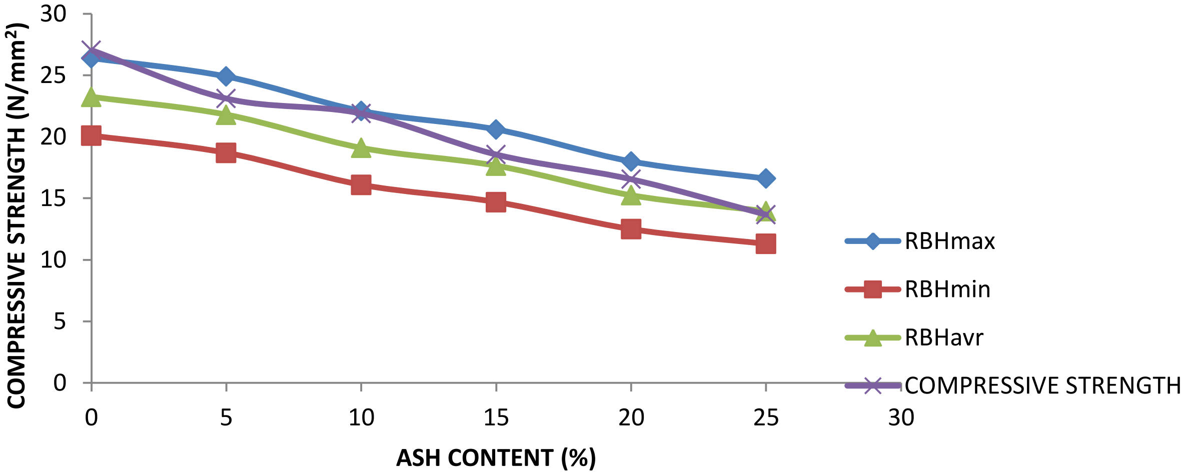



**figure 4.3 : variation in 7 day compressive strength results**

Table 4.5: Summary of 14 days compressive strength of OPC-CCA of concrete grade 30

| Ash content (%) | RBHmax (N/mm2) | RBHmin (N/mm2) | RBHavr (N/mm2) | Compressive strength (N/mm2) |
|---|---|---|---|---|
| 0 | 28.50 | 22.1 | 25.3 | 29.93 |
| 5 | 25.2 | 18.9 | 22.05 | 25.45 |
| 10 | 22.1 | 16.0 | 19.05 | 22.20 |
| 15 | 19.1 | 13.2 | 16.15 | 18.71 |
| 20 | 17.7 | 12.0 | 14.85 | 16.00 |
| 25 | 16.3 | 10.8 | 13.55 | 14.04 |

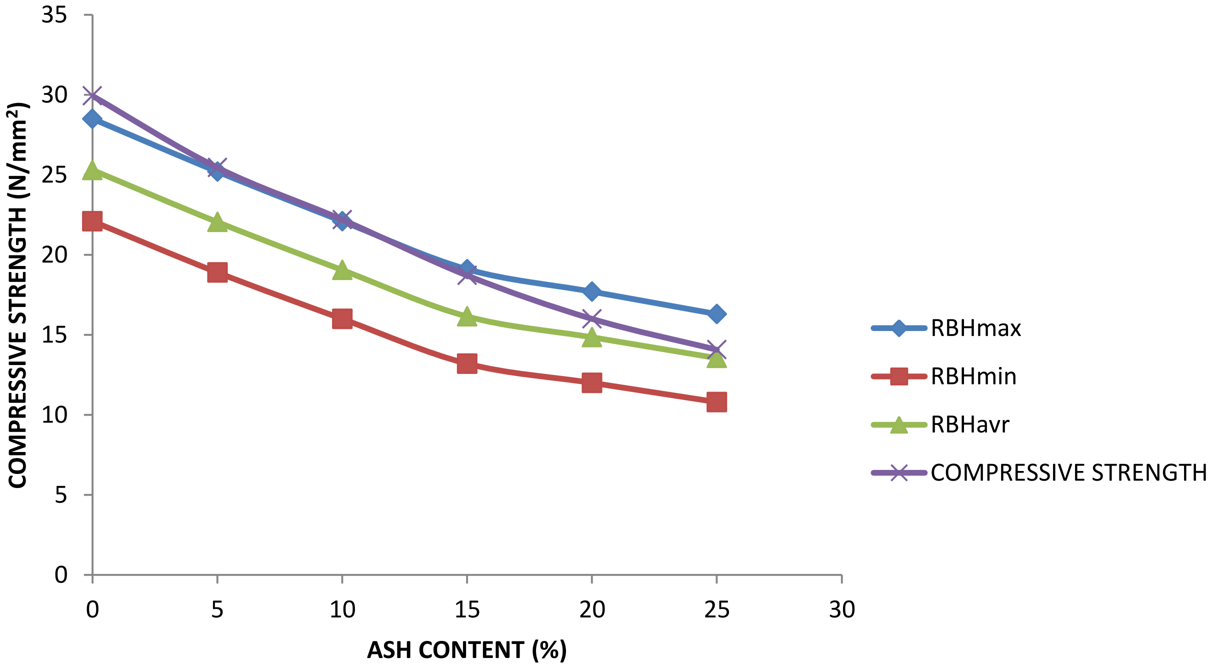



**figure 4.4: variation in 14 day compressive strength results**

Table 4.6: Summary of 28 days compressive strength of OPC-CCA of concrete grade 30

| Ash content (%) | RBHmax (N/mm2) | RBHmin (N/mm2) | RBHavr (N/mm2) | Compressive strength (N/mm2) |
|---|---|---|---|---|
| 0 | 30.1 | 23.5 | 26.8 | 30.3 |
| 5 | 28.5 | 22.1 | 25.3 | 28.78 |
| 10 | 26.90 | 20.50 | 23.70 | 26.22 |
| 15 | 23.6 | 17.5 | 20.55 | 22.33 |
| 20 | 22.1 | 16.00 | 19.05 | 20.27 |
| 25 | 20.6 | 14.6 | 17.6 | 17.33 |

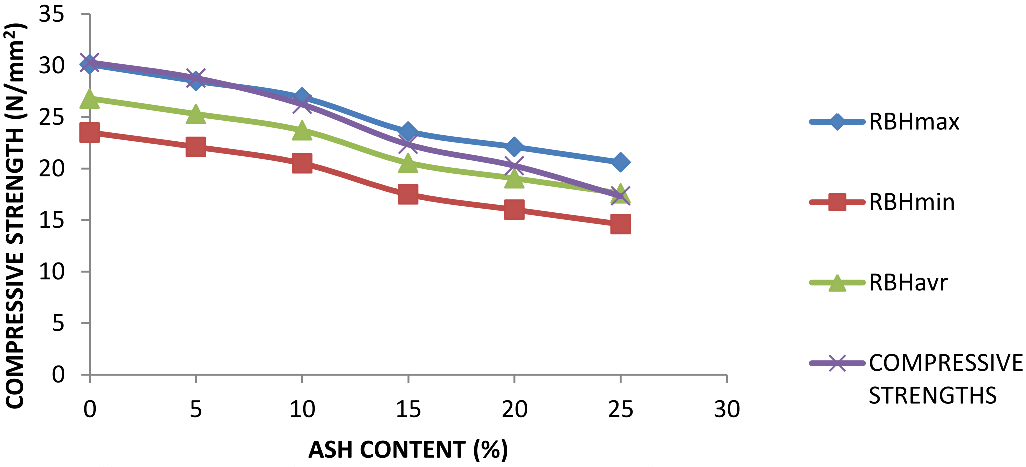
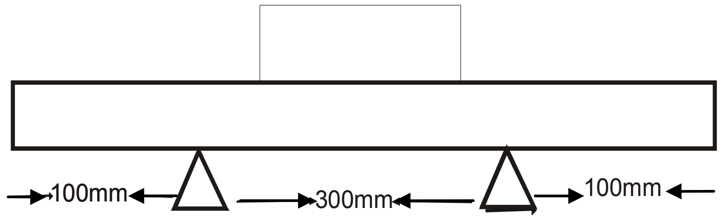



**figure 4.5: variation in 28 days compressive strength results**

The compressive strength of concrete cube cured for 7, 14 and 28 days of grade 30 using ordinary Portland cement and corn cob ash was further verified using rebound harmer and compared to that of compressive strength observed using (ELE) machine and plotted in the graphs of various ages shown above.

Flexural strength of rectangular beam




The figure shown above is illustration of rectangular beam with load and supports.
Hence, the flexural strength of the beam was computed using this equation:

R = PL/BD2……………………………………………………………………………..(iii)

Where; R = Flexural strength
P = Machine load
L = Beam span
B = Beam breadth
D = Beam depth

The flexural strength of concrete produced by partially replacing ordinary Portland cement with corn cob ash was also investigated by curing the rectangular beam for 28 day the results observed are here tabulated.

Table 4.7 Summary of flexural strength of concrete beams using percentage replacement of OPC-CCA using concrete grade 30

| Combination | 28days (N/mm2) |
|---|---|
| 0%CCA:100%Cement | 10.79 |
| 5%CCA: 95%Cement | 9.98 |
| 10%CCA: 90%Cement | 8.58 |
| 15%CCA:85Cement | 7.82 |
| 20%CCA:80%Cement | 6.56 |
| 25%CCA: 75% Cement | 5.72 |

The flexural strength for the indirect method decreases from 10.79N/mm2 (0% percent replacement) to 9.98N/mm2 (5% corn cob ash), 8.58N/mm2 (10% corn cob replacement), 7.82N/mm2 (15% corn cob replacement), 6.56N/mm2 (20% corn cob replacement) and 5.72N/mm2 (25% corn cob replacement) for concrete grade 30.

The figure below is a graph of the variation in flexural strength results at 28 days for grade 30 concrete with corn cob ash

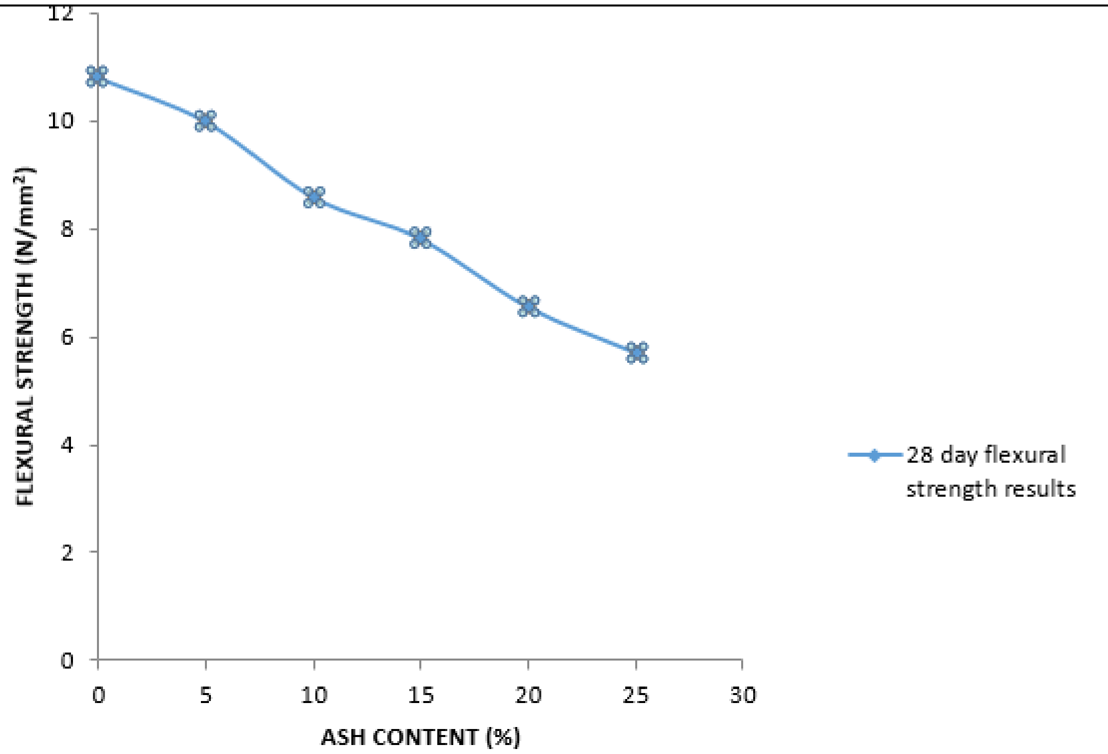



**figure 4.6: 28 day variation of flexural strength results of concrete grade 30 with CCA**

The concrete beam shows a significant decrease in flexural strength as indicated on the cart.

**CONCLUSION:**

The following conclusions were drawn from the study.

The setting time of cement increased with increase in corn cob ash (CCA) from 258minutes to 277minutes, when cement was replaced with 10%CCA.

CCA can be used to partially replace cement in the production of concrete to a maximum of 10%, because replacement beyond this reduced the concrete strength beyond the control.

The strength of concrete cubes and beams produced from replacement revealed that partial replacement of cement with CCA can be used to withstand some structural loads.

Replacement of this nature can also be used for walls and beams unit of buildings so as to reduce the use of cement and its high cost.

**RECONMENDATION:**

Based on the results of the test, it is recommended that 10% CCA is optimum for cement replacement. It is as well economical for use in concrete works.

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